GOOD PRACTICE CASE STUDY 390

Building management system in multi-site commercial and industrial buildings

Shell UK Exploration and Production – Aberdeen

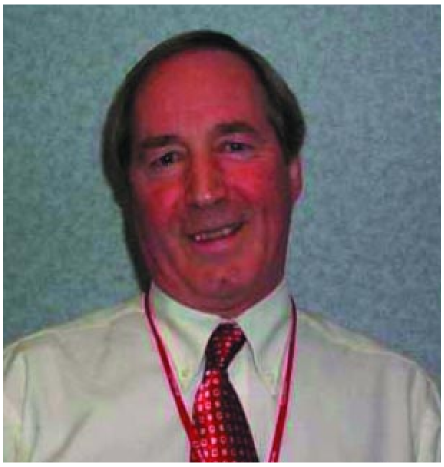
- Energy use reduced by 35% over four years
- Manpower savings of £120 000 per year
- Capital investment repaid in 4.5 years
- BMS covers:
  - – offices
  - – workshops
  - – warehouses
  - – leisure facilities
- BMS has led to improved management practices

BEST PRACTICE PROGRAMME

ENERGY EFFICIENCY

GOOD PRACTICE CASE STUDY 390

HOST COMPANY



Sandy Somerville, FM Contracts Manager, Shell UK Exploration and Production

'The introduction of a BMS to Shell's Aberdeen complex of offices, computer suite, laboratories and catering facilities in the early 1980s coincided with a growing awareness of the energy costs. The original BMS had limited capability by present-day standards, but proved to be an essential tool for the energy manager to make significant savings.

As part of Shell's forward-thinking approach to energy management, the advantages gained from the old system were used to provide a strong financial case for upgrading to a modern BMS in the mid-1990s.

All corporate expenditure requires a convincing financial case and whatever the difficulties I would encourage those contemplating a BMS or BMS upgrade to persevere with their case. A modern BMS is worth its weight in gold! We have used our system to continually improve levels of service while significantly reducing energy and manpower costs.'

SHELL UK EXPLORATION AND PRODUCTION

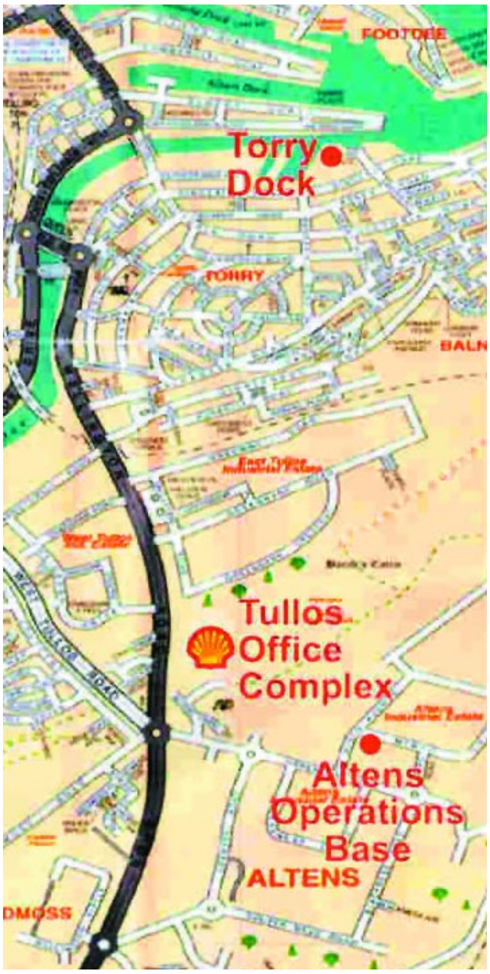


Figure 1 Location of sites around Aberdeen

SHELL EXPRO

Aberdeen is the headquarters of Shell Expro and consists of four principal sites within the City:

- Tullos – 42 500 m^2 office complex
- Altens Operations Base (AOB) – 35 acre storage site with 10 600 m^2 of warehouses, 2500 m^2 workshops and 900 m^2 offices
- Torry Dock – 5 acre industrial dockyard with 664 m^2 offices and 1575 m^2 warehouses
- Woodbank – 3500 m^2 conference facility.

Shell Expro employ over 2000 staff within the city, most of whom are based at the Tullos office complex, which provides commercial, administrative and computer support for the whole of Shell's UK operations. The site operates under a normal 07:00 to 17:00, Monday to Friday work pattern with staff working flexi-time. However, a small core of staff is required to operate the offshore control room 24 hours per day. Discrete functions as varied as dockyard warehousing and holding conferences are carried out at the other sites located across the City.

All sites, with the exception of Woodbank, are covered by the building management system (BMS), which monitors the energy performance at each site and provides control over the buildings' services.

The development and installation of the BMS at Shell Expro followed a classical route. An 'old style' BMS was introduced on one site 16 years ago. The benefits of this system were used to make a solid financial case for replacing it with a modern system in 1996. The modern system has now been expanded from a single site to providing comprehensive cover through a central supervisor over three sites located around Aberdeen. The comprehensive cover includes nearly all building services within the mix of office, industrial and warehouse facilities. An additional and important benefit has been the provision of data to guide the management's strategy for driving down energy costs still further.

Substantial energy and cost savings have been and continue to be made as a direct result of the BMS and the pro-active energy management strategies adopted.

INTRODUCTION

INTRODUCTION

This Case Study will be of interest to senior managers and facilities managers within large organisations, which, like Shell Expro, may have a number of disparate sites each requiring control and monitoring. As illustrated within this Case Study, the use of BMS in multi-site organisations will help management to improve their knowledge of, and control over, their buildings and operational facilities, which will lead to improved energy performance and reduced manpower requirements.

Figure 2 Aerial photographs of the three sites – in descending order Tullos, Altens and Torry Dock

WHAT IS A BUILDING MANAGEMENT SYSTEM?

A BMS is a microprocessor-based system, which provides the facility to control any building service. It works by using intelligent stand-alone controllers, or outstations, to accurately control plant (such as boilers, chillers, pumps, fans, lights and security systems) in response to changing conditions (such as time, temperature and light levels).

A system can begin with a single outstation, which can be expanded at any time by adding further outstations and linking them via a simple communications network, which in the case of geographically remote sites is a simple telephone line. The system can be enhanced by linking the outstations to a personal computer (PC) running appropriate applications. This will act as a management tool enabling all outstations to be monitored and adjusted from a central control point.

Individual outstations can significantly improve local control, however the full benefits of a BMS will only be seen once it becomes widespread and the advantages of the communications network and central control unit are realised. To this end BMSs are particularly beneficial in:

- building complexes
- complex buildings
- multi-site complexes
- facility-managed buildings.

The capabilities of a BMS are restricted only by cost and the user's commitment to control. User commitment is essential to get the best out of a BMS – without it the system will just be an under-used facility. Put simply, *a BMS provides an aid to management, not a substitute for it.*

BMSs are not new technology; they have been in use for over 30 years. However, they have become more common in the last five years due to the lower cost of microprocessors and advances in computer software, which make the systems much more user friendly.

DEVELOPMENT OF THE BMS AT SHELL EXPRO

DEVELOPMENT OF THE BMS AT SHELL EXPRO

Shell Expro first installed a BMS at the Tullos site in 1983 during the construction of their new phase-5 office building, which provided the opportunity for a BMS to be installed from the outset. A strong financial case was prepared which compared the installation costs of the BMS and relevant outstations with those of traditional stand-alone controls. The comparisons were not restricted to capital costs but also looked at the system's life-time operating costs, the effect on energy use and manpower requirements.

Over its life, the net present value (NPV) of the savings achieved through the BMS installation based upon an 8% discount rate is £1.3 million (equivalent to £2.6 million in 2000). The BMS installation cost £800 000, of which £330 000 would have been required to install standard controls. Allowing for this difference, the NPV would take just under three years to become positive.

Although the BMS initially cost more to install than standard controls, the energy and manpower savings achieved over its life more than offset the increase in capital outlay. The energy savings were achieved through better control over the hours of operation of the heating, ventilation and air-conditioning (HVAC) plant and the operation of the standby generators. In addition, the BMS provided a basic energy (and water) monitoring service which allowed management to identify improved housekeeping measures, such as switching off lights. To a limited extent the BMS also provided an aid to site security through monitoring fire alarms and door closures.

As part of the outsourcing of the site's facility management duties, Shell placed the BMS under the control of various facilities management companies. As none of these companies were given the task to use the BMS to reduce energy, its full potential was not realised. This was remedied when the more modern BMS was installed.

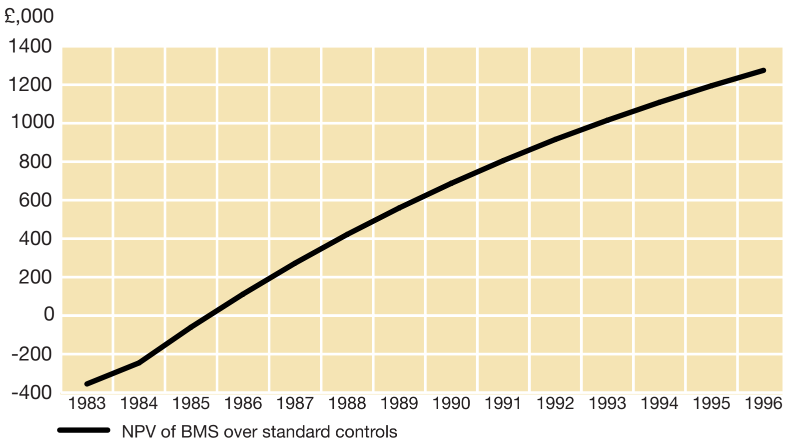


Figure 3 Net present value of savings for BMS over those of standard controls

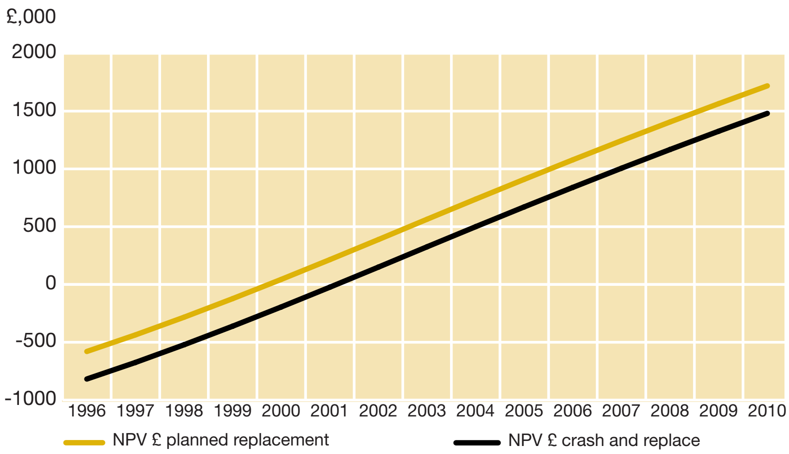
MODERN BMS

By 1994, the main computer controlling the BMS was obsolete and beginning to fail on a regular basis. A critical limitation of the system was its inability to start up back-up generators in the event of a mains supply outage, with the risk of a total loss of power to the site.

A feasibility study was carried out on the savings that could be achieved from a modern replacement through better energy management and reduced manpower costs based on the following options:

- do nothing – run with the existing system until failure, then revert to manual control
- crash and replace – run with the existing system until failure, then replace it (cost £750 000)
- planned replacement – replace the existing system during 1996 (cost £600 000).

Figure 4 Net present value of savings for planned replacement and crash and replace options over a do nothing approach



DEVELOPMENT OF THE BMS AT SHELL EXPRO

Over an expected life of 15 years, the NPV of the savings achieved through the planned replacement and crash and replace options are £1.7 million and £1.5 million respectively (see figure 4). For the planned replacement, the NPV becomes positive in around 4.5 years, while for the crash and replace option it takes nearly six years. The planned replacement route was clearly the most cost-effective and was consequently approved by the board.

Specialist consultants were employed to assess the sites' requirements and prepare a brief, which precisely defined the scope, extent and nature of the BMS solution required. The brief included the following:

- to provide close control over the building services, such as:
  - boiler plant
  - chillers
  - air-handling units
  - pumps
  - environmental (temperature) conditions
  - lighting
- to provide accurate data on building energy use
- to provide security through monitoring of door closures
- to be user friendly
- to provide training and support throughout the life of the BMS.

Figure 5 Tri-partite energy management team

As a result of a competitive tender, a new supplier was awarded the contract to provide the BMS. The cost of installing the new BMS, with very little of the existing system being re-used, was £600 000. This is about half of the cost, allowing for inflation, of the original BMS installed in 1983, reflecting the lower cost of microprocessors, advances in computer software and reduced commissioning costs.

EXPANDING THE SYSTEM

During the installation of the BMS at the Tullos site during 1996/7, the opportunity was taken to increase the number of sub-meters employed to improve the company's knowledge of energy usage and enable detailed monitoring and targeting to be undertaken. The BMS is also used to provide added site security through monitoring door closures.

In addition to servicing the main Tullos site, outstations were installed at the geographically remote sites of Torry Dock and Altens Operations Base (pipeyard), where it provided the same level of control over the respective plant and monitored energy use.

The expansion of the BMS to cover satellite sites was an essential element of the company's strategy. By providing a central point of control over the geographically remote sites, significant savings in manpower were achieved, with maintenance engineers only needing to visit sites when problems were identified through the system. Shell has estimated that the introduction of the BMS across its Aberdeen sites has reduced manpower costs by £120 000 per year compared to continuing to operate with standard controls.

The expansion of the system to satellite sites was, and is still being, carried out, either when their existing controls become due for replacement or when budgets permit. However, as the cost of outstations is little more than that of standard controls, the additional capital cost of extending the system is negligible.

ENERGY MANAGEMENT AND PERFORMANCE ASSESSMENT

ENERGY MANAGEMENT

To coincide with the upgrading of the BMS, Shell have adopted a proactive approach to energy management. To this end, Shell have signed up to the Making a Corporate Commitment campaign which commits them to responsible energy management and the promotion of energy efficiency throughout their operations.

Energy management structure

Energy management was added to the facilities management contract with Balfour Beatty and a disciplined energy control regime was put in place. Balfour Beatty operate the BMS to control services and compile monthly data on water and energy consumption. Specialist energy management consultants, Nifes, were brought in as sub-contractors to Balfour Beatty to analyse the consumption data and identify areas where improvements can be made. This is achieved through a slave (ie duplicate) BMS supervisor unit installed in Nifes' Glasgow offices. Shell, Balfour Beatty and Nifes meet monthly to discuss energy performance and highlight opportunities for further energy savings.

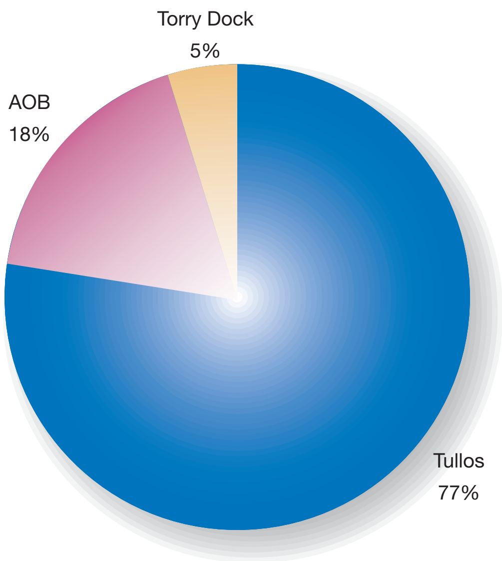


Figure 6 Energy use at each site in 1999

ENERGY PERFORMANCE ASSESSMENT

Energy use by Shell's Aberdeen sites is dominated by the office complex at Tullos which accounts for over two-thirds of the total energy use. The introduction of the BMS and the appointment of Balfour Beatty in 1996/7 have led to substantial reductions in energy use at all sites, which, combined with improved purchasing practices, has driven the energy costs even lower.

Energy use overall has been reduced by almost 14 million kWh (35%) between 1996 and 1999, saving the company £260 000 at 1999 prices. The savings result from investment in many areas, including lighting and radiant heaters for warehouses. However, the full benefit of these could only have been realised through the control and monitoring achieved through the BMS and the energy management team's commitment.

The greatest level of savings was achieved during the first year of the BMS installation when control over services was significantly improved.

Monitored information provided by the BMS was also used by the management team to highlight areas of wastage, such as extensive operating hours of plant, excessive temperatures, and heating and lighting of unoccupied areas. The management team used this information to identify the 'low-lying fruit' and make changes to those areas where clear and obvious savings could be made.

Further significant savings have been achieved year on year through fine tuning the BMS and continuing the good work through the management team.

Site	Electricity (kWh)	Fossil fuel (kWh)	Total (kWh)	Cost (£)
Tullos	9 358 600	10 171 858	19 557 458	415 812
AOB	1 516 730	3 112 379	4 629 106	87 839
Torry Dock	630 730	564 340	1 195 070	34 272
Total	**11 506 060**	**13 848 577**	**25 381 634**	**537 923**

Table 1 1999 annual energy use and cost for each site

ENERGY MANAGEMENT AND PERFORMANCE ASSESSMENT

Site	Annual energy consumption (kWh)			
	96	97	98	99
Tullos	30 344 333	23 920 687	21 138 477	19 335 189
AOB	6 947 013	5 267 652	4 856 877	4 561 096
Torry Dock	1 582 639	1 423 705	1 289 933	1 182 739
TOTAL	**38 873 985**	**30 612 044**	**27 285 287**	**25 079 024**

Table 2 Annual energy consumption 1996 to 1999 (fossil fuel is degree day corrected to UK 20 year average – 2462)

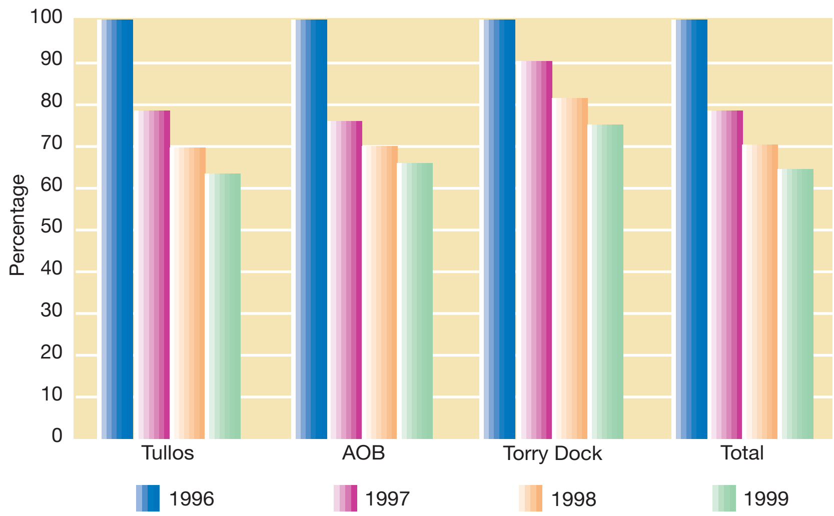


Figure 7 Percentage changes in energy consumption compared with a base year of 1996

Environmental benefits

Carbon emissions produced by the burning of fossil fuels to produce energy, is recognised as one of the main contributors to global warming. The introduction of the BMS and the energy management practices at Shell Expro have achieved energy savings of 35% over the last four years, which corresponds to a reduction in carbon emissions of 1000 tonnes per year.

FUTURE PLANS

Through regular meetings, the management team has developed many other plans for further reducing energy use. Examples of such developments are as follows.

- A 1 MW CHP plant is proposed for installation at the Tullos site with potential to feed electricity back into the grid for offtake by other Shell sites in Aberdeen. This would, to a large extent, be controlled through the BMS.
- A condition maintenance programme is to be installed onto the BMS to replace the current planned maintenance approach. This is to be introduced in 2000 and will significantly reduce maintenance time and manpower requirements.
- The lighting control system at Tullos is being expanded across the whole site as and when refurbishment work is undertaken. The system provides time control over lights and also dims them in response to available daylight.

CASE STUDIES – TULLOS

1 TULLOS

The 26 acre site has office accommodation and extensive laboratory and catering facilities totalling 42 547m^2 gross internal area (38 292 m^2 treated). Approximately 1600 staff and 150 support staff are employed on flexi-time during the hours of 07:00 to 19:00, Monday to Friday. About 10% of the site, including the offshore control room and laboratory, is continuously occupied.

Comparing the Tullos consumption with the benchmarks, figure 8 shows that fossil fuel use at 254 kWh/m^2/year is better than typical levels, while electricity use at 245 kWh/m^2/year is well below what is considered to be good practice.

Much of the credit for this good performance can be attributed to the control achieved through the BMS and automated lighting control system.

Automated lighting control is provided in about 60% of the site and is extended into remaining areas as part of the ongoing site refurbishment programme. The system provides occupancy and daylight control and, along with the introduction of high-frequency lights, is responsible for reducing electricity consumption for lighting by about 40%.

Further significant energy savings have been achieved by putting control of the chillers for the air-conditioning system onto the BMS. The chillers were previously controlled manually which often lead to the system operating continuously to satisfy

peak conditions. However, the BMS now optimises their performance and matches their loading to suit demand requirements. This has provided significant energy cost savings of about £45 000 per year and has also reduced maintenance time and ensures that satisfactory conditions are maintained.

Figure 8 Comparison of Tullos consumption with benchmarks

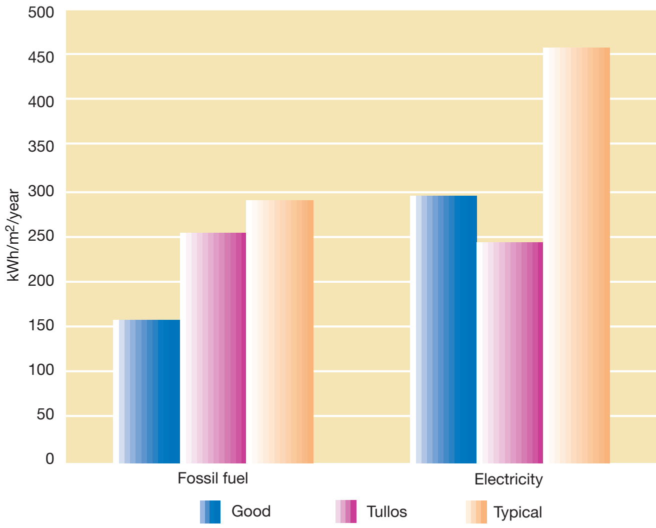


Table 3 Calculation of good practice and typical benchmarks

Office type	Floor area (%)	Weekly occupancy hours	Weekly design hours	Hours correction	Fossil fuel benchmark Typical	Fossil fuel benchmark Good practice	Electricity benchmark Typical	Electricity benchmark Good practice
1	6	62	48	1.29	195	102	70	43
2	0	0	58	0.00	–	–	–	–
3	9	89	62	1.43	255	139	324	183
4	82	89	67	1.33	278	151	474	310
Lab	2	115	67	1.72	1150	624	1520	993
	99							
Benchmarks for building mix kWh/m^2/year					**290**	**157**	**459**	**297**

Good practice and typical benchmarks have been constructed using ECON 18 and ECON 19 (EEBPp), adjusted to suit the extended hours of operations and mixed use of buildings covered.

CASE STUDIES – ALTENS OPERATIONS BASE

2 ALTENS OPERATIONS BASE

This site covers 35 acres, which is mainly used for storage. The buildings within the site comprise of four warehouses with a footprint area of 10 600 m^2, a 2500 m^2 workshop and 900 m^2 of office space. Operating hours are 07:00 hours to 21:00 hours, Monday to Friday, and there is a permanent security presence on the site. For security reasons, the main warehouse and external areas are permanently lit. The site employs approximately 200 people.

Comparing the AOB consumption with the benchmarks, figure 9 shows that fossil fuel use at 212 kWh/m^2/year is close to good practice levels and electricity use is below typical, at 72 kWh/m^2/year but above what is considered to be good practice. The good gas usage levels can be attributed to the much improved control achieved through the BMS and the introduction of radiant heating in two warehouses.

Through the energy management tri-partite meetings, it was suggested that the oil-fired warm air heaters used throughout warehouses should be replaced with gas-fired radiant heaters. As a trial, this was carried out at two of the warehouses with the heaters' control being put through the BMS. The energy-saving benefits of this have been monitored through the BMS which has shown that the space-heating energy use in the two warehouses has reduced by 25%. The effectiveness of this measure has encouraged Shell to replicate the change throughout their industrial warehouses in Aberdeen.

Figure 9 Comparison of Altens consumption with benchmarks

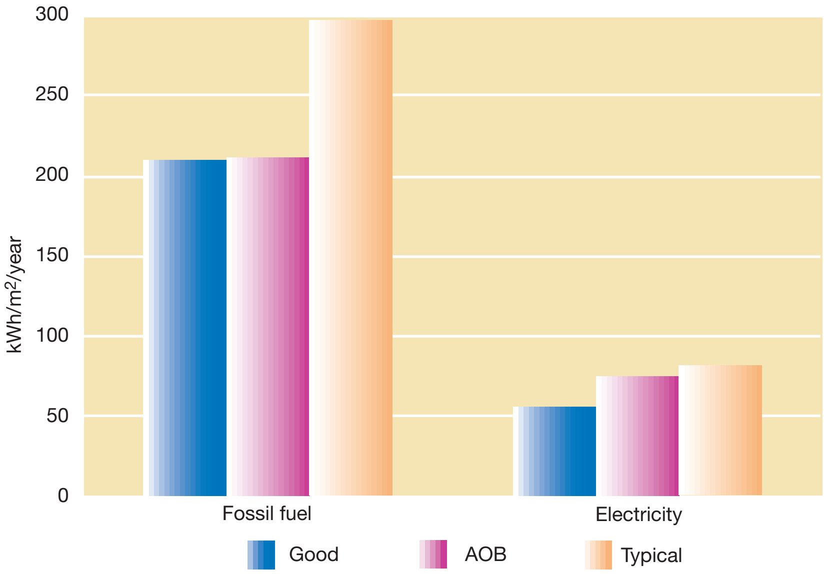


Table 4 Calculation of good practice and typical benchmarks

Building type	Floor area (%)	Weekly occupancy hours	Weekly design hours	Hours correction	Fossil fuel benchmark Typical	Fossil fuel benchmark Good practice	Electricity benchmark Typical	Electricity benchmark Good practice
Warehouse	75	98	60	1.633	302	221	70	47
Factory office	17	77	60	1.283	289	193	128	92
Engineering	8	60	68	0.882	265	154	75	57
	100							
Benchmarks for building mix kWh/m^2/year					**297**	**211**	**80**	**56**

Good practice and typical benchmarks have been constructed using ECON 18 and ECON 19 (EEBPp), adjusted to suit the extended hours of operations and mixed use of buildings covered.

CASE STUDIES – TORRY DOCK

3 TORRY DOCK

This site covers five acres and is comprised of a 664 m^2 shipping office and two warehouses with a combined footprint area of 1575 m^2. The site is manned by 50 staff. Core operating hours are 07:00 hours to 21:00 hours, Monday to Friday. However, there is a permanent security and offshore liaison presence at the site. For security reasons, the main warehouse and external areas are extensively lit beyond the normal working day.

Comparing the Torry Dock consumption with the benchmarks, figure 10 shows that fossil fuel and electricity use at 241 and 79 kWh/m^2/year respectively are between good practice and typical, which for a site of this age and construction is a considerable achievement. The good fossil fuel (oil) usage levels can be attributed to the improved time control provided through the BMS.

Information provided through the BMS prompted an energy survey to be carried out at Torry Dock. This identified that substantial levels of lighting were maintained in the warehouses during unoccupied periods. The attention of on-site staff was drawn to this and a good housekeeping strategy was put in place. This has resulted in cost savings of £3500 per year – equivalent to 10% of the site's total electricity costs.

Figure 10 Comparison of Torry Dock consumption with benchmarks

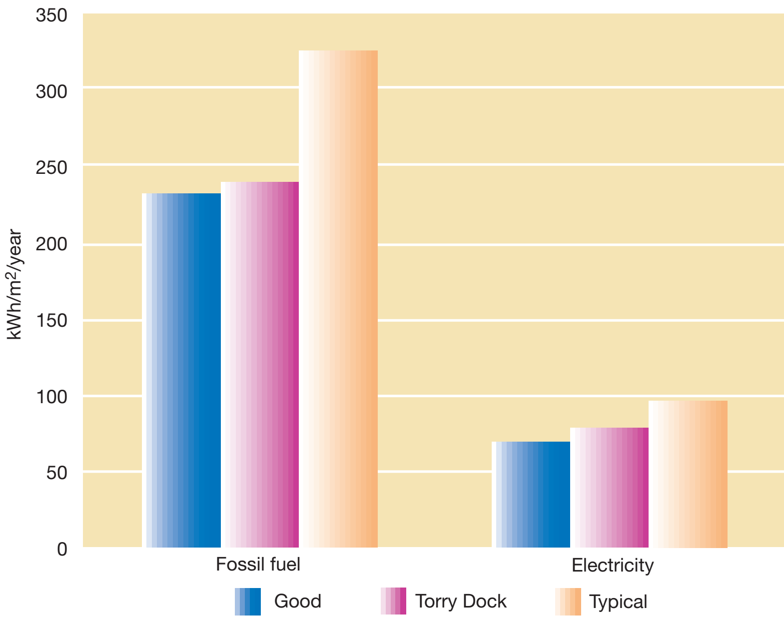


Table 5 Calculation of good practice and typical benchmarks

Building type	Floor area (%)	Weekly occupancy hours	Weekly design hours	Hours correction	Fossil fuel benchmark Typical	Fossil fuel benchmark Good practice	Electricity benchmark Typical	Electricity benchmark Good practice
Warehouse	70	98	60	1.633	302	221	70	47
Factory office	30	98	60	1.633	368	245	163	118
	100							
Benchmarks for building mix kWh/m^2/year					**322**	**228**	**98**	**68**

Good practice and typical benchmarks have been constructed using ECON 18 and ECON 19 (EEBPp), adjusted to suit the extended hours of operations and mixed use of buildings covered.

FURTHER READING

ENERGY EFFICIENCY BEST PRACTICE PROGRAMME DOCUMENTS

The following Best Practice programme publications are available from the BRECSU and ETSU Enquiries Bureau. Contact details are given below.

Energy Consumption Guides

18 Energy efficiency in industrial buildings and sites (BRECSU)
19 Energy use in offices (BRECSU)

Good Practice Guides

69 Investment appraisal for industrial energy efficiency (ETSU)
112 Monitoring and targeting in large companies (ETSU)
119 Organising energy management – a corporate approach (BRECSU)
125 Monitoring and targeting in small and medium-sized companies (ETSU)
246 Building management systems in further and higher education (BRECSU)
303 The designer's guide to energy-efficient buildings for industry (BRECSU)
304 The purchaser's guide to energy-efficient buildings for industry (BRECSU)

Good Practice Case Studies

388 Energy-efficient design of new industrial buildings – a step-by-step approach by Process Combustion Ltd (BRECSU)
391 Energy-efficient refurbishment of industrial buildings – a strategic management approach by Marconi Applied Technologies (BRECSU)

This Case Study is based on material drafted by Briar Associates under contract to BRECSU for the Energy Efficiency Best Practice programme.

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Energy Consumption Guides: compare energy use in specific processes, operations, plant and building types.

Good Practice: promotes proven energy-efficient techniques through Guides and Case Studies.

New Practice: monitors first commercial applications of new energy efficiency measures.

Future Practice: reports on joint R&D ventures into new energy efficiency measures.

General Information: describes concepts and approaches yet to be fully established as good practice.

Fuel Efficiency Booklets: give detailed information on specific technologies and techniques.

Introduction to Energy Efficiency: helps new energy managers understand the use and costs of heating, lighting, etc.